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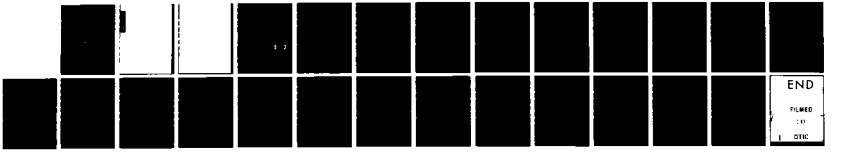

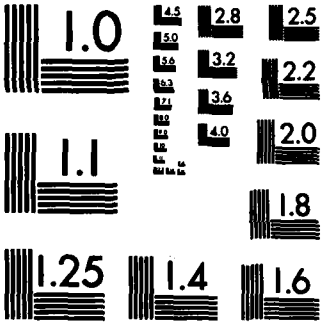

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

ADVANCED ELECTRONIC TECHNOLOGY

QUARTERLY TECHNICAL SUMMARY REPORT TO THE AIR FORCE SYSTEMS COMMAND

1 MAY — 31 JULY 1982

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LEXINGTON MASSACHUSETTS

INTRODUCTION

This Quarterly Technical Summary covers the period 1 May through 31 July 1982. It consolidates the reports of Division 2 (Data Systems) and Division 8 (Solid State) on the Advanced Electronic Technology Program.

TABLE OF CONTENTS

DATA SYSTEMS

DIVISION 2

INTRODUCTION

This section of the report reviews progress during the period 1 May through 31 July 1982 on Data Systems. Separate reports describing other work of Division 2 are issued for the following programs:

Seismic Discrimination	ARPA/DSO
Distributed Sensor Networks	ARPA/IPTO
Defense Switched Network Technology	OSD-DCA
Digital Voice Processing	AF/ESD
Digital Voice Interoperability Program	AF/ESD
Packet Speech Systems Technology	ARPA/IPTO
Radar Signal Processing Technology	ARMY/BMDATC
Restructurable VLSI	ARPA/IPTO
Multi-Dimensional Signal Processing	AF/RADC

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Head, Division 2

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DIGITAL INTEGRATED CIRCUITS
GROUP 23

I. INTRODUCTION

A 16-cell whole-wafer Phase 0 integrator has been laser programmed and has been operated at low frequencies. Fabrication has begun on the Phase 1 integrator. Difficulties in developing a two-level-metal process compatible with laser links are now understood, and the modified process appears to be reliable.

II. RVLSI CIRCUITS

A. Phase 0 Integrator

The Phase 0 integrator wafer has a 5 × 5 array of 4-bit-counter cells in which the interconnect is fully testable. One of these wafers has been laser programmed to connect a 4 × 4 array of counters. After cell and interconnect testing, the wafer was mounted in a package. Functional testing was done on the laser table after the connection of each new cell. The full array was functional at low speeds, but a few high-impedance links prevented high-speed operation. These links were located by deduction from package testing and knowledge of the interconnect pattern, and by some probing of the wafer. It was determined that the initial laser power had been set too low and the high impedance links were fixed by an additional pulse. Fully successful operation is now prevented by some probing damage.

B. RVLSI Spread-Spectrum Integrator

Fabrication of the whole-wafer RVLSI integrator has begun. The system comprises three cell types: the basic 4-counter cell and input and output cells. Triple redundancy of the counter cells is provided on the 3-in. wafer, and double redundancy for the simpler I/O cells. Care was taken to design the interconnect for testability. Continuity of stubs on two sides of the counter cell will be tested when the cells are tested for functionality after completion of first-level metal fabrication. Wafer-probe capacitance measurements have proved to be very effective in finding defective

interconnect lines. All the lines will have probe pads for such measurements. The interconnect is designed to provide ample redundancy, but only about 12 percent of the possible link positions are populated. This sparseness of links reduces capacitance and permits denser packing of tracks.

C. FFT for Radar Applications

Processing and testing have been completed on the first wafer containing FFT cells. The multiplier-accumulator cells were found to have a low-resistance short circuit between VDD and VSS which prevented meaningful functional testing of these circuits. By laser cutting, optical probing, and SEM analysis it was determined that the shorts were caused by holes in the polyimide where first metal, polysilicon, and second metal all crossed. The defect resulted from an improper polyimide etching procedure, which has since been corrected.

The parallel-serial converter cells use significantly less second metal for interconnect within the circuit, and did not exhibit this problem with shorts. However, early in testing it was determined that a control signal within the circuit was always high. The cause for this was traced to a mask layout error on second metal, which has been corrected with no delay to the remaining wafers being processed. The circuit otherwise performed as expected.

Processing will be completed shortly on the next two wafers. With correction of the two problems described above, it should be possible to fully test both cell types.

D. High-Speed Functional Testing

During this quarter, programs were written for the Tektronix S-3260 tester to test the Phase 0 and Phase 1 integrators and the FFT chip. A new prober has been ordered to allow wafer probing with the 3260.

E. Circuit Design Aids

The geometric design rule checking program for our CMOS process is operational on the VAX computer for all twelve levels through second-level metal and passivation. A node extractor, based on the same framework and primitives, has been added. It allows a functional check of the circuit

after mask layout. Input levels and clock signals are specified and the corresponding output signals are generated. This makes it possible to find errors in wiring or logic before the processing is started.

These tools are an extension of Lincoln Laboratory work supported by DARPA. They have been successfully applied to the RVLSI integrator and I/O cells now being processed.

III. RESTRUCTURABLE VLSI TECHNOLOGY

A. Laser-Formed Links

The RVLSI laser links have been found to form connections at up to 3.5 W laser power before failures occur. The exact failure mode is currently being investigated. At the low-power end of the linking range the threshold for connection occurrence was found to vary from 1.35 to 1.7 W from wafer to wafer, and even for different areas on a given wafer. Current investigations suggest that these changes are caused by nonuniformity in the 10-nm-thick CVD barrier oxides which sandwich the a-Si link insulator. Changes in the oxide process have improved this uniformity on a wafer to ±3 percent, from the previous ±20-percent value. This should reduce the threshold variations and increase the already large window for connection formation. It has been found that some links made below the threshold will show high resistances which can be corrected by a second zap from the laser.

The wafer table system has been fully integrated with the VAX computer to generate and control the full wafer linking patterns. A full 16-cell Phase 0 integrator has been linked up using this system and is currently being tested.

B. Lifetime Tests on RVLSI Links

Initial electromigration studies on a few links have been encouraging. On 4 of the 5 links tested at 100°C and 50 mA, the metal line leading to the link failed after 44 h while the link itself remained operational. In one case, the exact position of the failure has not yet been identified. More extensive tests are just beginning.

C. Polyimide Links

The charred polyimide lateral link described in the preceding Quarterly Technical Summary* has proven quite successful. Two thousand links have been made across 7- to 15-μm gaps with resistances in the 1-kohm range. Above a threshold power, and with a specific pattern of laser zaps, there have been no failures (links >10 kohms) in the tests to date.

D. Laser System

A second laser linking system has been assembled and is operational.

IV. SEMICONDUCTOR PROCESSING

A. Lithography

Tests with 3-in. wafers have shown that we can expect more variable image acuity, presumably due to greater waviness in the larger wafers. An analysis to determine which exposure-focus settings among the several acceptable combinations will give the most uniform results over all of the wafer is being done. Additionally, we are evaluating resist image dimensions on the wafer compared with reticle dimensions in order to determine proper reticle dimension compensation.

B. Dry Etching

Use of Freon 13 for polysilicon plasma etching may be producing excessive undercut. Freon 13 was chosen for its isotropic etch characteristics in order to assure good step coverage of the polysilicon by subsequent layers. However, evidence of nonuniformity in line width across the wafer and unsatisfactory wafer-to-wafer and run-to-run etch-rate repeatability has caused us to review this process. Use of Freon 115 gives much more anisotropic etching and may be required to attain the line-width control and repeatability which are needed.

C. Two-Level Metal

A series of experiments with the inter-metal via process has revealed that our use of 300 W RF power at 80-mTorr O_2 pressure for plasma etching

*Quarterly Technical Summary, Advanced Electronic Technology, Lincoln Laboratory, M.I.T. (15 May 1982).

polyimide has been sputtering material from the resist into the via opening. Improper removal of this photoresist/polyimide debris led to poor electrical contact between levels of metal, as well as difficulty in forming laser links. Changing the plasma etch schedule to 100 to 200 W at 250 mTorr for the polyimide etching, followed by a 50-W, 80-mTorr cleanup step, eliminates these effects. This process produces vertical-walled vias with no undercut. Via resistance in the latest test is low (~1 ohm) and yield high (>99.9 percent) for nominal size down to $4 \times 4\ \mu m^2$.

The high etching power at low pressure also caused resist to etch faster than polyimide and resulted in metal-metal shorts in FFT cells. In the revised process, the two materials etch at the same rate and the i[illegible]ation defect density is low.

D. CMOS Processing

The initial CMOS run fabricated on 3-in. wafers was processed [illegible]gh the first-metal test. The data indicate that circuit yield should [illegible] comparable to that experienced with 2-in. wafers to within 8 mm of a wafer's edge. PSG coverage and plasma etch uniformity are the primary yield detractors in the edge region. Additional work will be required to improve the yield in that outer region since the Phase 1 full wafer integrator contains structures to within 5 mm of the edge of a 3-in. wafer at the corners of the array.

V. DEVICE THEORY

A. Nitrided Oxide

Very preliminary results indicate nitriding substantially improves the radiation resistance of field as well as gate oxides. Infrared data indicate a substantial degree of nitridation of 5000-Å oxides, as contrasted to published reports by Ito et al.*

*T. Ito et al., J. Electrochem. Soc. 127, 2053 (1980).

B. Electrical Properties of Thin Oxides and Nitrided Oxides

Initial efforts to examine interface states vs NH_3 exposure have been impeded by a surface ion problem which produces an inversion region well beyond the Al electrode area. This spurious effect can be eliminated with a guard band structure which necessitates more complex processing. Initial results on the interface state issue do not show significant increases due to NH_3 exposure.

C. The Role of Silicon 3d Electrons in Silicon Dioxide and Silicon Nitride

There has been speculation that the normally empty Si 3d atomic orbitals should interact with the occupied O and N lone-pair orbital in SiO_2 and Si_3N_4, respectively, giving rise to p-d pi bonding and Si d electrons in these materials. Detailed electronic structure calculations show negligible mixing of Si 3d orbitals with the lone-pair orbitals of either material. Thus, the speculation concerning the existence of d electrons in SiO_2 and Si_3N_4 would appear not to be substantiated.

Nevertheless, both Si $L_{2,3}$ x-ray emission spectroscopy (XES) and Si $L_{2,3}$ VV Auger emission spectroscopy (AES) of both SiO_2 and Si_3N_4 show peaks which can be attributed to Si 3d electrons. Resolution of this dilemma appears to be associated with the necessary creation of initial Si $L_{2,3}$ core-hole states during both Si $L_{2,3}$ XES and Si $L_{2,3}$ VV AES. Initial state relaxation due to the presence of the core hole lowers the energy of the Si 3d atomic orbital allowing mixing with lone-pair orbitals and, hence, the formation of localized Si 3d electrons. Thus, the 3d electrons appear to be an artifact of the measurements.

COMPUTER SYSTEMS

GROUP 28

Two major changes to the internal data communications network have been completed during this quarter. Access to the Amdahl V/8 central computer by switched data lines was completely redesigned when the Laboratory cut over to a new internal digital telephone system. In addition to voice service, the new system, a Northern Telecom SL1-XL, provides internal data rates up to 9600 baud using unique digital signaling. Data access to and from the regular outside plant of the New England Telephone Company analog network has been improved by providing more lines and greater switching capabilities in the Computer Center.

Relocation of some fifty directly wired terminals to a new building, approximately 2000 ft from the Computer Center, required a major installation effort. Because of the distance, Lincoln-developed "short-haul" modems, previously reported on, are being used for low-speed devices employing standard RS-232-C interfaces. These involve data rates up to 4800 baud, carried over twisted-pair connections. Considerably higher rates, used by alphanumeric display terminals, are carried by direct runs of RG-62U coaxial cable. Facilities for future expansion using cable multiplexing and connection of the Lincoln Internal Data Link (LIDL) have been included in this service extension.

After more than ten years of service, Lincoln's ARPA Network IMP has been replaced by a BBN C/30 Communications Processor. The change required less than a day and was essentially transparent to Lincoln's current hardware and software interfaces. Work on the new ARPA protocol and Amdahl V/8 access to the Network through a PDP-11/44 gateway is progressing. LIDL software has been interfaced to the UNIX operating system on the 11/44, and files have been transferred to another DEC computer on the Link. Software connecting Amdahl V/8 users to the ARPA Network via LIDL is now being tested.

SOLID STATE
DIVISION 8

INTRODUCTION

This section of the report summarizes progress during the period 1 May through 31 July 1982. The Solid State Research Report for the same period describes the work of Division 8 in more detail. Funding is primarily provided by the Air Force, with additional support provided by the Army, DARPA, Navy, NASA, and DOE.

A.L. McWhorter
Head, Division 8

I. Melngailis
Associate Head

DIVISION 8 REPORTS
ON ADVANCED ELECTRONIC TECHNOLOGY

15 May through 15 August 1982

PUBLISHED REPORTS

Journal Articles

JA No.			
5250	A Calculation of the Capacitance-Voltage Characteristics of p^+-InP/n-InP/n-InGaAsP Photodiodes	J.P. Donnelly	Solid-State Electron. 25, 669 (1982)
5274	Photodeposition of Metal Films with Ultraviolet Laser Light	D.J. Ehrlich R.M. Osgood, Jr. T.F. Deutsch	J. Vac. Sci. Technol. 21, 23 (1982)
5305	Amorphous-Crystalline Boundary Dynamics in cw Laser Crystallization	H.J. Zeiger J.C.C. Fan B.J. Palm R.L. Chapman R.P. Gale	Phys. Rev. B 25, 4002 (1982)
5314	Laser Remote Sensing of Hydrazine, MMH, and UDMH Using a Differential-Absorption CO_2 Lidar	N. Menyuk D.K. Killinger W.E. DeFeo	Appl. Opt. 21, 2275 (1982)
5316	Tantalum Oxide Capacitors for GaAs Monolithic Integrated Circuits	M.E. Elta A. Chu L.J. Mahoney R.T. Cerretani W.E. Courtney	IEEE Electron Device Lett. EDL-3, 127 (1982)
5319	Microsecond Carrier Lifetimes in Si Films Prepared on SiO_2-Coated Si Substrates by Zone-Melting Recrystallization and by Subsequent Epitaxial Growth	B-Y. Tsaur J.C.C. Fan M.W. Geis	Appl. Phys. Lett. 41, 83 (1982)
5325	Integrated Optical Temperature Sensor	L.M. Johnson F.J. Leonberger G.W. Pratt*	Appl. Phys. Lett. 41, 134 (1982)
5328	Stimulated Surface-Plasma-Wave Scattering and Growth of a Periodic Structure in Laser-Photodeposited Metal Films	S.R.J. Brueck D.J. Ehrlich	Phys. Rev. Lett. 48, 1678 (1982)
5330	Zone-Melting Recrystallization of 3-in.-diam Si Films on SiO_2-Coated Si Substrates	J.C.C. Fan B-Y. Tsaur R.L. Chapman M.W. Geis	Appl. Phys. Lett. 41, 186 (1982)
5341	Submicrometer-Linewidth Doping and Relief Definition in Silicon by Laser-Controlled Diffusion	D.J. Ehrlich J.Y. Tsao	Appl. Phys. Lett. 41, 297 (1982)

*Author not at Lincoln Laboratory.

JA No.			
5342	Effects of Ionizing Radiation on n-Channel MOSFET's Fabricated in Zone-Melting-Recrystallized Si Films on SiO_2	B-Y. Tsaur J.C.C. Fan G.W. Turner D.J. Silversmith	IEEE Electron Device Lett. EDL-3, 195 (1982)
5344	Direct-Write Metallization of Silicon MOSFET's Using Laser Photodeposition	J.Y. Tsao D.J. Ehrlich D.J. Silversmith R.W. Mountain	IEEE Electron Device Lett. EDL-3, 164 (1982)
5355	Remote Sensing Conference Focuses on Technological Advances in Measurement	N. Menyuk	Laser Focus 18, 12 (1982)
5364	Opically-Induced Microstructures in Laser Photodeposited Metal Films	R.M. Osgood, Jr. D.J. Ehrlich	Opt. Lett. 7, 385 (1982)

Meeting Speeches

MS No.			
5760	Transient Heating with Graphite Heaters for Semiconductor Processing	J.C.C. Fan B-Y. Tsaur M.W. Geis	In Laser and Electron-Beam Interactions with Solids, B.R. Appleton and G.K. Celler, Eds. (Elsevier North Holland, Amsterdam, 1982), pp. 751-758
5763	Preparation of Oriented GaAs Bicrystal Layers by Vapor-Phase Epitaxy Using Lateral Overgrowth	J.P. Salerno R.W. McClelland P. Vohl J.C.C. Fan W. Macropoulos C.O. Bozler A.F. Witt*	In Grain Boundaries in Semiconductors, H.J. Leamy, G.E. Pike, and C.H. Seager, Eds. (Elsevier North Holland, Amsterdam, 1982), p. 77
5767	Silicon-on-Insulator MOSFETs Fabricated in Zone-Melting-Recrystallized Poly-Si Films on SiO_2	B-Y. Tsaur M.W. Geis J.C.C. Fan D.J. Silversmith R.W. Mountain	In Laser and Electron-Beam Interactions with Solids, B.R. Appleton and G.K. Celler, Eds. (Elsevier North Holland, Amsterdam, 1982), pp. 585-590
5899A	Raman Scattering as a Probe of Thin-Films	S.R.J. Brueck	Proc. Workshop on Diamond-Like Carbon Coatings, Albuquerque, New Mexico, 19-20 April 1982
5925	Heterodyne Experiments from Millimeter Wave to Optical Frequencies Using GaAs MESFETs Above f_T	A. Chu H.R. Fetterman D.D. Peck P.E. Tannenwald	Microwave and Millimeter Wave Symposium Digest, Dallas, Texas, 16-18 June 1982, p. 25

*Author not at Lincoln Laboratory.

MS No.			
5927	A Two-Stage Monolithic IF Amplifier Utilizing a Ta_2O_5 Capacitor	A. Chu L.J. Mahoney M.E. Elta W.E. Courtney M.C. Finn W.J. Piacentini J.P. Donnelly	Microwave and Millimeter Wave Symposium Digest, Dallas, Texas, 16-18 June 1982, p. 61

* * * * *

UNPUBLISHED REPORTS

Journal Articles

JA No.			
5346	Low-Dislocation-Density GaAs Epilayers Grown on Ge-Coated Si Substrates by Means of Lateral Epitaxial Overgrowth	B-Y. Tsaur R.W. McClelland J.C.C. Fan R.P. Gale J.P. Salerno B.A. Vojak C.O. Bozler	Accepted by Appl. Phys. Lett.
5347	High-Speed UV- and X-Ray-Sensitive InP Photoconductive Detectors	T.F. Deutsch F.J. Leonberger A.G. Foyt D. Mills*	Accepted by Appl. Phys. Lett.
5352	Graphoepitaxy of Germanium on Gratings with Square Wave and Sawtooth Profiles	M.W. Geis B-Y. Tsaur D.C. Flanders	Accepted by Appl. Phys. Lett.
5354	Deep-UV Spatial-Period-Division Using an Excimer Laser	A.M. Hawryluk* H.I. Smith* R.M. Osgood, Jr.* D.J. Ehrlich	Accepted by Opt. Lett.
5361	Limitations of Signal Averaging Due to Temporal Correlation in Laser Remote Sensing Measurements	N. Menyuk D.K. Killinger C.R. Menyuk*	Accepted by Appl. Opt.
5362	Analysis of Integrated-Optics Y-Junction and Mach-Zehnder Interferometric Modulator Using Four-Port Scattering Matrix	R.H. Rediker F.J. Leonberger	Accepted by IEEE J. Quantum Electron., Special Issue on Guided-Wave Technology
5363	Wideband Monolithic Acousto-electric Memory Correlators	R.A. Becker R.W. Ralston P.V. Wright	Accepted by IEEE Trans. Sonics Ultrason.
5369	Spatial Light Modulation Using Electroabsorption in a GaAs CCD	R.H. Kingston B.E. Burke K.B. Nichols F.J. Leonberger	Accepted by Appl. Phys. Lett.
5370	Lateral Epitaxial Overgrowth of GaAs by Organometallic Chemical Vapor Deposition	R.P. Gale R.W. McClelland J.C.C. Fan C.O. Bozler	Accepted by Appl. Phys. Lett.

*Author not at Lincoln Laboratory.

MS No.			
5377	Time-Resolved Measurements of Stimulated Surface Polariton Wave Scattering and Grating Formation in Pulsed-Laser-Annealed Germanium	D.J. Ehrlich S.R.J. Brueck J.Y. Tsao	Accepted by Appl. Phys. Lett.
5378	2-Bit 1 Gigasample/sec Electro-optic Guided-Wave Analog-to-Digital Converter	R.A. Becker F.J. Leonberger	Accepted by IEEE J. Quantum Electron.

Meeting Speeches*

MS No.			
5653C	Frequency Stability and Control Characteristics of (GaAl)As Semiconductor Lasers	A. Mooradian D. Welford	Frequency Control Symp., Philadelphia, Pennsylvania, 2-4 June 1982
5707H	Laser Photophysics of Surface Adlayers	D.J. Ehrlich T.F. Deutsch	XIIth International Quantum Electronics Conference, Munich, Germany, 22-25 June 1982
5805	Advances in Tunable Transition-Metal Lasers	P.F. Moulton	
5904	Optical Exclusive OR Gate	H.A. Haus† A. Lattes† E.P. Ippen† F.J. Leonberger	
5905	Doubly Degenerate Four-Wave Mixing in $LiNbO_3$ Waveguides	H.A. Haus† A. Lattes† C. Gabriel† E.P. Ippen† F.J. Leonberger	
5910	Fundamental Line Broadening Mechanisms of Single-Frequency CW (GaAl)As Diode Lasers	D. Welford A. Mooradian	
6018A	Stimulated Surface Plasma Waves and the Formation of Periodic Structures by Laser Irradiation of Surfaces	D.J. Ehrlich S.R.J. Brueck J.Y. Tsao	
5805A	Advances in Tunable Transition-Metal Lasers	P.F. Moulton	SPIE Technical Symposium East, Arlington, Virginia, 3-7 May 1982
5837	A High-Speed CCD Two-Dimensional Correlator	B.E. Burke A.M. Chiang W.H. McGonagle G.R. McCully J.F. Melia	

*Titles of Meeting Speeches are listed for information only. No copies are available for distribution.

†Author not at Lincoln Laboratory.

MS No.			
5883A	Performance Characteristics of a 4-Bit 828-Megasample/s Electrooptic Analog-to-Digital Converter	F.J. Leonberger R.A. Becker	SPIE Technical Symposium East, Arlington, Virginia, 3-7 May 1982
5821D	Millimeter-Wave Monolithic Circuits	A. Chu	IEEE Intl. Microwave Symp., Dallas, Texas, 15-17 June 1982
5908	Passive Superconducting Microwave Circuits for 2-20 GHz Bandwidth Analog Signal Processing	J.T. Lynch A.C. Anderson R.S. Withers P.V. Wright S.A. Reible	
5829A	Analog Processing with Superconducting Circuits	E. Stern	Seminar, IBM, Yorktown Heights, New York, 14 June 1982
5866A	MNOS/CCD Nonvolatile Analog Memory	R.W. Ralston R.S. Withers	Industrial Liaison Seminar, M.I.T., 20 May 1982
5869	Zone-Melting Recrystallization of Three-Inch-Diameter Silicon Films on SiO_2-Coated Substrates	J.C.C. Fan R.L. Chapman B-Y. Tsaur M.W. Geis	The Electrochemical Society Mtg., Montreal, Canada, 9-14 May 1982
5870	Properties of Zone-Melting-Recrystallized Si Films on Insulators	B-Y. Tsaur J.C.C. Fan M.W. Geis D.J. Silversmith R.W. Mountain	
5891	Dry Etching of Gold Using SF_6	S.M. Cabral M.E. Elta A. Chu L.J. Mahoney	
5893	The Mechanism of Orientation of Si Graphoepitaxy Using a Strip-Heater Oven	H.I. Smith* M.W. Geis	
5919A	Remote Sensing of Hydrazine Compounds Using a Dual Mini-TEA CO_2 Laser DIAL System	N. Menyuk D.K. Killinger W.E. DeFeo	JANAF Remote Sensing of Propellants, NBS, Washington, DC, 21 July 1982
5935	Limitations of Signal Averaging of DIAL Measurements Due to Temporal Correlation	N. Menyuk D.K. Killinger C.R. Menyuk*	11th International Laser Radar Conference, Madison, Wisconsin, 21-25 June 1982
5946	Simultaneous Heterodyne and Direct Detection CO_2 DIAL Measurements	D.K. Killinger N. Menyuk W.E. DeFeo	
5939	Lateral Epitaxial Growth of InP Over PSG Films for Oxide-Confined Optical Waveguides	P. Vohl F.J. Leonberger F.J. O'Donnell	Electronic Materials Conf., Ft. Collins, Colorado, 23-25 June 1982

*Author not at Lincoln Laboratory.

MS No.			
5958	Direct-Write Metallization of Si MOSFETs Using Laser Photodeposition	J.Y. Tsao D.J. Ehrlich D.J. Silversmith R.W. Mountain	Electronic Materials Conf., Ft. Collins, Colorado, 23-25 June 1982
5967	Zone-Melting-Recrystallized Si Films: Characteristics and Prospects for Device Applications	B-Y. Tsaur J.C.C. Fan M.W. Geis R.L. Chapman D.J. Silversmith R.W. Mountain G.W. Turner	
5976	Control of Subboundaries in Zone-Melting Recrystallized Si Films	M.W. Geis H.I. Smith* B-Y. Tsaur J.C.C. Fan D.J. Silversmith R.W. Mountain	
5940	Laser Photochemical Processing for Microelectronics	D.J. Ehrlich T.F. Deutsch J.Y. Tsao	Industrial Liaison Symp., M.I.T., 4 May 1982
5960A	Liquid-Phase Epitaxy	Z.L. Liau	Optical Information Systems, Inc., Elmsford, New York, 16 July 1982
6019	Atmospheric Transmission Measurement Limitations Due to Temporal Correlation	N. Menyuk D.K. Killinger C.R. Menyuk*	Annual Review Conf. on Atmospheric Transmission Models, Air Force Geophysics Laboratory, Hanscom AFB, Bedford, Massachusetts, 18-20 May 1982
6032	Buried Heterostructure GaInAsP/InP Lasers Fabricated Using Thermally Transported InP	Z.L. Liau J.N. Walpole	Device Research Conf., Ft. Collins, Colorado, 21-23 June 1982
6033	Heterodyne and Direct Detection at 10 μm with High-Temperature p-Type HgCdTe Photoconductors	D.L. Spears	IRIS Specialty Group on IR Detectors, San Diego, California, 27-29 July 1982
6035	High-Quality $Hg_{1-x}Cd_xTe$ Epilayers Grown by Open-Tube VPE	P. Vohl D.L. Spears	
6041	Effects of Ionizing Radiation on SOI MOSFETs Fabricated in Zone-Melting-Recrystallized Si Films	B-Y. Tsaur J.C.C. Fan G.W. Turner D.J. Silversmith	Nuclear and Space Radiation Effects Symp., Las Vegas, Nevada, 20-22 July 1982
6094	High-Efficiency Solar Cells	J.C.C. Fan	DOE Energy Research Advisory Panel, Solar Energy Research Institute, Golden, Colorado, 1 July 1982

*Author not at Lincoln Laboratory.

SOLID STATE

DIVISION 8

I. SOLID STATE DEVICE RESEARCH

Low bending losses have been achieved in single-mode Ti:$LiNbO_3$ channel waveguides by utilizing coherent coupling effects between closely spaced abrupt bends. Losses as low as 0.08 dB per coupled 1° abrupt bend, as compared with 0.8 dB per isolated 1° abrupt bend, have been measured. Low-loss waveguide bends are needed for the efficient interconnection of optical components in integrated optical circuits.

Threading dislocations were found not to influence the dark current of high-performance InP avalanche photodiodes formed using liquid phase epitaxially grown n-p^+ junctions on moderate-dislocation-density substrates. This result is in marked contrast to the previously reported effect of dislocations on diodes formed by diffused junctions. It is hypothesized that, when the junction is formed by diffusion, the dislocations act as channels for enhanced diffusion.

High-speed one- and two-dimensional light modulation may be carried out using the electroabsorption (Franz-Keldysh) effect in a GaAs buried channel charge-coupled device (CCD). For photon energies slightly lower than the energy gap, the transmission through or along the surface of a CCD structure may be controlled by the signal charge in the wells through the change of electric field with charge. Experimental measurements on a GaAs CCD structure designed with semitransparent gates have verified the predicted performance.

II. QUANTUM ELECTRONICS

A dual-wavelength, dual-CO_2-laser, differential-absorption LIDAR system has been developed which permits simultaneous heterodyne detection and direct detection of the same LIDAR returns. Differences in signal-to-noise ratios and statistical and temporal characteristics for LIDAR returns from topographic targets have been measured.

A new, high-gain, solid state tunable laser, Ti:Al_2O_3, has been demonstrated. Pulsed operation with up to 1 mJ of output energy and tuning from 718 to 770 nm have been observed.

Preliminary experiments have been carried out to adapt recently developed laser direct-write techniques to the discretionary deposition of conducting links in VLSI circuits. Both photochemical and thermal laser-deposition techniques have produced low-resistance links on simple single-level, metal-gap structures.

In order to generate tunable radiation at power levels suitable for use as a heterodyne local oscillator, a submillimeter crossed-guide frequency doubler has been developed which operates up to 600 GHz in the fundamental mode. This doubler also yields excellent performance when used for both harmonic and fundamental mixing.

III. MATERIALS RESEARCH

In the first demonstration of lateral epitaxial overgrowth by organometallic chemical vapor deposition (OMCVD), ratios of lateral to vertical growth rates greater than five have been achieved for the deposition of GaAs. To show the applicability of OMCVD to the CLEFT (cleavage of lateral epitaxial films for transfer) process, a continuous epitaxial GaAs layer 3 μm thick has been grown over a patterned mask on a GaAs substrate, then bonded to a glass substrate and cleaved intact from the GaAs substrate.

Nominally undoped, n-type crystals of InP grown by the liquid-encapsulated Czochralski method from In-rich melts exhibit a marked decrease in carrier concentration and increase in mobility at 77 K compared with those grown from stoichiometric melts. Measurements of the Hall coefficient at room temperature as a function of magnetic field up to 15 T indicate that this improvement in electrical properties is due to a reduction in donor concentration rather than to measurement anomalies resulting from the presence of In inclusions.

An ion-implantation technique has been developed for use in the fabrication of metal-oxide-semiconductor field-effect transistors (MOSFETs)

for large-scale integrated circuits. In an initial demonstration of this technique, a p-type wafer was coated with a thin layer of W and then with alternating layers of Si and W, after which it was implanted with As^+ ions. Thermal annealing produced a shallow WSi_2/Si ohmic contact and simultaneously activated the implanted As donors to form a shallow p-n junction located directly below the contact.

A study has been made of the effects of irradiation with 1.5-MeV electrons and Co-60 γ-rays on the electrical characteristics of n-channel MOSFETs, with either complete-island-etch or local-oxidation-of-Si isolation, that were fabricated in zone-melting-recrystallized Si films on SiO_2-coated Si substrates. As in a previous study, which was limited to electron irradiation of complete-island-etch devices, it was found that radiation effects can be largely suppressed by applying a moderate negative bias to the substrates during irradiation and device operation.

IV. MICROELECTRONICS

An all-CCD time-integrating correlator has been built by combining on a single chip binary-analog charge multiplication, charge integration, and subtraction of the integrated bias charge. All the design functions of the chip have been verified at a 5-MHz clock rate; modifications of the chip layout will be made to achieve the 25-MHz clock rate potential of the CCD.

Sulfur hexafluoride has been used in a reactive ion etching system to etch both Au and GaAs. Straight walls with no undercut are achieved when etching Au with SF_6 at lower power densities and bias levels than with Ar sputter etching, and the resulting etched surfaces are smoother for SF_6 etching. Minmal damage is introduced to etched GaAs when using SF_6, as evidenced by ideality factor measurements on diodes fabricated on etched and unetched surfaces.

V. ANALOG DEVICE TECHNOLOGY

Test results on 32-sample MNOS/CCD nonvolatile analog memories show that the devices immediately after writing are linear over a 5-V window with an

rms fixed pattern deviation of 28 mV, thus providing a 39-dB linear dynamic range. After 10^5 erase/write (E/W) cycles, signal retention is unchanged, but significant degradation occurs after 10^7 E/W cycles. Design, fabrication, and initial testing of a 256-sample MNOS/CCD analog memory have also been carried out.

In order to fully realize the potential of superconductive microwave filters for analog signal processing, there has been a need for a rugged, readily available, isotropic substrate material having a very low ($<10^{-4}$) dielectric loss tangent and low dispersion at 1- to 10-GHz frequencies. Measurements of niobium-on-silicon stripline resonators have shown that the silicon substrate possesses all the desirable properties.

An improved configuration for an integrated optical spectrum analyzer is proposed which utilizes an amplitude-weighted, oblique-incidence-grating input lens, a bulk-acoustic-wave Bragg cell excited by a quadrature-fed planar phased array, a Fresnel output lens, and an integrated Si detector array fed through channel waveguides. The optical energy is confined by low-loss glass waveguides on passivated Si except in the Bragg cell.

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